Effect of NaCl and KCl to the Growth and Nutrient Level of Upland Rice in an Ultisol

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Abstract: We evaluated the effects of KCl substitution by NaCl on the growth and nutrient level of upland rice an Ultisol during four months in Panca Budi Experimental Farm, Medan, Indonesia. The study used a two-factor randomized block design with three replications. The first factor is NaCl, consisting of 5 levels. namely: 0 mg NaCl/polybag; 118 mg NaCl/polybag; 235 mg NaCl/polybag; 350 mg NaCl/polybag and 470 mg NaCl/polybag. The second factor is KCl, consistingof 5 levels namely 0 mg KCl/polybag, 150 mg KCl/polybag, 300 mg KCl/polybag, 450 mg KCl/polybag and 600 mg KCl/polybag.The results showed that NaClsignificantly increased the nutrient levels of N, P, Na, KCl also significantly increased the nutrients levels of N, P, K. However, NaCl and KCl applications did not increase the growth of upland rice. The effect of KCl substitution by NaCl to 100% (470 mg/polybag)did not decrease the growth and nutrient levels of the plant.

1 INTRODUCTION

Fertilizer continues to increase in line with agricultural intensification efforts around the world in general and in Indonesia in particular. Accordingly, the price of fertilizer continues to rise due to increasing price of energy used to produce the fertilizer (Subowo, 2010).

The rising price of fertilizer has encouraged developing countries to make low-cost efforts to increase agricultural production such as the utilization of micro-organisms that can fertilize the soil. Algae, Rhizobium and Azolla are now being used to fix N (nitrogen) from the air as well as mycorrhizae to increase the ability of plants to absorb P (phosphorus) from the soil. There is no microorganism that can be utilized for K (potassium) because the element is not in the air and minerals are generally soluble easily (Elmer, 2004).

According to Emery (in Yufdy and Jumbar, 2018) seawater contains many ions which result in high salinity and the distribution of nutrients in seawater is influenced by sea water circulation, biological processes and mineralization and nutrient regeneration and supply from land. Naturally, leached nutrient from the mainland is only a small part back to the land, enriching the sea with nutrients. Some nutrients dissolve in the sea water and some settle at the bottom. Manurung states that it is the time to take advantage of nutrients in the sea. The sea salts can be produced in a very simple and inexhaustible way, because sea salt is a waste of the process of soil leaching, a natural process that will not stop.

The main component of sea salt is NaCl. The sodium chloride is considered to replace some KCl fertilizers for various crops or used as additional fertilizer for the crops. Other components useful materials for agriculture are Ca, Mg, S, K, P and various micro elements. Since NaCl is not harmful to many crops, then it can be used as fertilizer. Besides saving the use of KCl fertilizer through partial replacement by NaCl, will also obtain a number of other elements contained in the salt (Kusumiyati, et al., 2017).

The research aimed to study the effect of KCl substitution by NaCl on the growth and nutrients level of upland rice.

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2 METHODOLOGY

The research was conducted in Panca Budi Experimental Farm, Medan, Indonesia. The soils used as growing medium are Ultisol taken from TanjungMorawa, North Sumatra. Soil analysis showed that K-exchangeable is 0.65 me/100 g and Na exchangeable is 0.08 me/100 g. The upland rice seed is Kalimutu varieties. The fertilizer used is Urea (45% N) and TSP (46% P_2O_5) as basic fertilizer and KCl (60% K_2O) and NaCl used is ordinary salt (52.03% Na_2O). Pesticides used are insecticides Curater 2 G, Benlate, Bassa 50 EC, Sevin 85 S, Diazonin, Zine phosphide and fungicide Fongorene 50 WP to control pests and diseases.

The study use randomized two factors block design with three replications. Treatment of NatriumChlorida (NaCl = 52,03% Na_2O) is: Na0 = 0 kg NaCl/ha = 0 mg NaCl/polybag; Na1 = 29.40 kg NaCl/ha = 118 mg NaCl/polybag; Na2 = 58.85 kg NaCl/ha = 235 mg NaCl/polybag; Na3 = 88.35 kg NaCl/ha = 350 mg NaCl/polybag' Na4 = 118.20 kg NaCl/ha = 470 mg NaCl/polybag. Treatment of PottasiumChlorida (KCl = 60% K_2O) is: K0 = 0 kg KCl/ha = 0 mg KCl/polybag; K1 =37.5 kg KCl/ha = 150 mg KCl/polybag; K2 = 75.0 kg KCl/ha = 300 mg KCl/polybag; K3 = 112.5 kg KCl/ha = 450 mg KCl/polybag; K4 = 150.0 kg KCl/ha = 600 mg KCl/polybag. The level of NaCl treatment was adjusted with the recommended dosage of KCl fertilizer in upland rice, where the equation was K = Na. The parameters recorded are growth and levels of nutrient plants. Nutrient levels of N and P plants were analyzed by auto analyzer. Nutrient levels of K and Mg plants were analyzed by ASS (Atomic Absorption Spectrofotometer). The data was analyzed using SPSS.

3 RESULT

3.1 The Plant Growth

Analysis of variance showed that application of NaCl and KCl and their interaction did not show significant effect on the plant growth including plant height, number of productive tillers and number of tillers at 4 weeks after planting until flowering time.

Table 1: Effect of KCl and NaCl to the Growth Upland Rice.

Treatment	Observation Variable		
NaCl (mg/polybag)	Plant Height (cm)	Number of Tillers (tillers)	Number of Productive Tillers (tillers)
0	128.13	5.60	5.93
118	129.13	5.74	6.40
235	130.08	5.40	6.07
350	129.12	5.80	5.80
470	128.61	5.67	6.07
KCl (mg/polybag)			
0	127.57	5.80	5.73
150	129.33	5.67	5.73
300	128.19	5.60	6.33
450	129.17	5.27	6.20
600	130.92	5.87	6.27

Table 1 shows that the application of KCl up to 600 mg/polybag and NaCl up to 470 mg/polybag does not show a significant difference compared to the control, as well as the combination of these two factors do not show a significant difference to the plant height. The combination without KCl and NaCl 470 mg/polybag (K_0Na_4) results not much different from the application of KCl 600 mg/polybag and without the application of NaCl (K_0Na_4). This showed that the application of NaCl to 470 mg/polybag did not reduce the high of upland rice on soil with K content of 0.65 me/100 g soil and Na content of 0.08 me/100 g soil.

Table 1 shows that the application of KCl up to 600 mg/polybag and NaCl up to 470 mg/polybag does not show a significant difference compared to the control, as well as the combination of these two factors do not show a significant difference on the number of tillers. Results of combination without KCl and NaCl 470 mg/polybag (K_0Na_4) is not much different from the application of KCl 600 mg/polybag and without the application of NaCl (K_0Na_4). This showed that the application of NaCl to 470 mg/polybag did not reduce the number of tiller of upland rice.

Table 1 shows that the application of KCl up to 600 mg/polybag and NaCl up to 470 mg/polybag does not show a significant difference on the number of productive tillers compared to the control, as well as the combination of these two factors does not show a significant difference. Results of combination without KCl and NaCl 470 mg/polybag (K_0Na_4) is not much different from the application of KCl 600 mg/polybag and without the application of NaCl (K_4Na_0). This showed thatthe application of

NaCl up to 470 mg/polybag did not reduce the number of productive tiller of upland rice. Generally, KCl application up to 600 mg/polybag and NaCl up to 470 mg/polybag do notsuppress the growth of upland rice.

3.2 Effect of KCl Substitution by NaCl of the Growth of Upland Rice

From Table 1,it can be presented the results of research on the effect of KCl replacement by NaCl on plant height, number of tillers and number of productive tillers as presented in Table 2 below.

Table 2: Effect of KCl Substitution by NaCl to the Growth Upland Rice.

Treatment	Observation Variable		
KCl Substitutions NaCl	Plant Height (cm)	Number of Tillers (tillers)	Number of Productive Tillers (tillers)
0% KCl 0% NaCl	122.97	5.00	5.00
100% KCl 0% NaCl	133.83	6.33	6.33
75% KCl 25% NaCl	130.67	5.67	6.33
50% KCl 50% NaCl	131.33	5.67	6.33
25% KCl 75% NaCl	130.33	5.67	5.33
0% KCl 100% NaCl	132.33	6.00	6.33

Table 2 shows that KCl substitution by NaCl up to 100% did not show any significant difference on plant height, number of tillers and number of productive tillers. This means that replacing KCl by NaCl up to 100% does not prevent or inhibit the plant metabolic process so there is no difference in growth between KCl 100% treatment with KClsubstitutionby NaCl up to 100% but looks better than control although not significantly different. This shows that the substitutionof KCl by NaCl does not negatively affect plant growth.

Growth on salty soils is directly related to plant resistance to osmotic pressure and poisoning by specific ions, such as Na^+ and Cl^-. These ions move to plant roots zone through mass flow. Before reaching the critical threshold, the accumulation of ions can still be tolerated so that no toxic effects occur.

Sabban (2012) states that the effect of sodium chloride or salt on plant growth is related to maintaining water content in the leaves and is associated with Na and K ion pumps

This is in line with the research finding that soil physical and chemical properties are not adversely affected by NaCl application. Na content is considered to be harmful to the soil physical state if the percentage of Na-exchangeable exceeds 10% (Hayward, 1947 *in*Sabban, 2012). In this study, the percentage of Na-exchangeable is still below 3%.

3.3 Nutrient Level

The result of analysis of variance showed that NaCl significantly increased N, P and Na concentration but did not indicate significantly effect on K and Mg. KCl fertilizers significantly increase the nutrient content of N, P and K and decrease the concentration of Na, but has no significant effect on Mg. The interaction did not show any significant effect on all parameters measured.

Table 3: Effect of KCl and NaCl to the N level (%).

KCl treatment (mg/polybag)	NaCl (mg/polybag)					Average
	0 (Na_0)	118 (Na_1)	235 (Na_2)	350 (Na_3)	470 (Na_4)	
0 (K_0)	3.29	3.27	3.24	3.35	3.38	3.31 a
150 (K_1)	3.30	3.31	3.32	3.31	3.34	3.32 a
300 (K_2)	3.32	3.34	3.37	3.33	3.45	3.36 ab
450 (K_3)	3.31	3.31	3.46	3.40	3.48	3.39 ab
600 (K_4)	3.43	3.43	3.43	3.43	3.46	3.44 b
Average	3.33a	3.33a	3.36ab	3.36ab	3.42b	

Note: Data in the same column and row followed by the common letters are not significantly different at the 5% levels according to the LSD test

Application of NaCl significantly increased the nutrient content of N of upland rice at 470 mg/polybag while KCl significantly increased the nutrient content of N at 600 mg/polybag, but the combination of both factors did not significantly affect the nutrient content of N.

The increased dose of NaCl applied will increase N content of upland rice. Susanti (2017) states that

NaCl levels have a significant effect on all growth parameters and yield of lettuce. Thus the use of NaCl is very beneficial because the upland rice will be more efficient using the given nutrients. Increasing N nutrient levels of upland rice due to KCl application may due to function of potassium to balance the anion and affect the extraction as well as transport of the anion.

Table 4: Effect of KCl and NaCl to the P level (%).

KCl treatment (mg/polybag)	NaCl (mg/polybag)					Average
	0 (Na_0)	118 (Na_1)	235 (Na_2)	350 (Na_3)	470 (Na_4)	
0 (K_0)	0.12	0.13	0.13	0.12	0.13	0.12 a
150 (K_1)	0.12	0.13	0.13	0.13	0.13	0.13 b
300 (K_2)	0.13	0.13	0.13	0.13	0.14	0.13 b
450 (K_3)	0.12	0.13	0.13	0.14	0.14	0.13 b
600 (K_4)	0.13	0.13	0.13	0.13	0.14	0.13 b
Average	0.12 a	0.13b	0.13b	0.13b	0.14b	

Note: Data in the same column and row followed by the common letters are not significantly different at the 5% levels according to the LSD test

KCl significantly increased the nutrient content of P at 600 mg/polybag, but the combination of both factors did not significantly affect the nutrient content of P.

The increased dose of NaCl and KCl applied will increase P content of upland rice. This is due to better condition of soil P-available that can be absorbed by plant.

Table 5: Effect of KCl and NaCl to the K level (%).

KCl treatment (mg/polybag)	NaCl (mg/polybag)					Average
	0 (Na_0)	118 (Na_1)	235 (Na_2)	350 (Na_3)	470 (Na_4)	
0 (K_0)	2.24	2.24	2.23	2.22	2.18	2.22 a
150 (K_1)	2.34	2.31	2.31	2.30	2.23	2.30ab
300 (K_2)	2.40	2.39	2.35	2.31	2.32	2.35ab
450 (K_3)	2.45	2.40	2.34	2.34	2.31	2.37ab
600 (K_4)	2.56	2.47	2.43	2.42	2.34	2.44 b
Average	2.39a	2.36a	2.33a	2.32a	2.28a	

Note: Data in the same column and row followed by the common letters are not significantly different at the 5% levels according to the LSD test

Table 6: Effect of KCl and NaCl to the Mg level (%).

KCl treatment (mg/polybag)	NaCl (mg/polybag)					Average
	0 (Na_0)	118 (Na_1)	235 (Na_2)	350 (Na_3)	470 (Na_4)	
0 (K_0)	0.28	0.27	0.29	0.30	0.26	0.28
150 (K_1)	0.27	0.29	0.32	0.29	0.29	0.29
300 (K_2)	0.28	0.28	0.30	0.32	0.30	0.30
450 (K_3)	0.32	0.32	0.30	0.31	0.30	0.31
600 (K_4)	0.32	0.30	0.34	0.31	0.33	0.32
Average	0.30	0.29	0.31	0.31	0.31	

Note: Data in the same column and row followed by the common letters are not significantly different at the 5% levels according to the LSD test

Application of KCl fertilizer up to 600 mg/polybag and NaCl at 470 mg/polybag showed no significant effect on Mg nutrient content of upland rice, as well as combination did not show significant effect on Mg. This indicates that application of NaCl up to 470 mg/polybag did not significantly decrease Mg nutrient content.

Table 7: Effect of KCl and NaCl to the Na level (%).

KCl treatment (mg/polybag)	NaCl (mg/polybag)					Average
	0 (Na_0)	118 (Na_1)	235 (Na_2)	350 (Na_3)	470 (Na_4)	
0 (K_0)	76.00ab	301.00abcdef	378.00def	427.00ef	536.67f	343.7b
150(K_1)	69.00ab	172.67abcde	307.00bcdef	344.00cdef	531.33f	284.8b
300(K_2)	68.67ab	99.33abc	152.33abcd	173.67abcde	472.33f	193.2a
450(K_3)	63.67ab	83.33abc	110.33abcd	130.67abcd	464.00f	172.2a
600(K_4)	56.67 a	75.67ab	103.67abc	123.67abcd	418.00ef	155.5a
Average	66.80a	146.40ab	212.13bc	239.80cd	484.47d	

Note: Data in the same column and row followed by the common letters are not significantly different at the 5% levels according to the LSD test

Application of KCl significantly decreases the nutrient content of Na of upland rice while NaCl significantly increased the nutrient content of Na. The combination of both factors has significantly affected on the nutrient content of Na.

Na leaf content increased with increasing NaCl applied that is from 66.80 ppm increased to 484.47 ppm by NaCl application. This is a logical consequence because NaCl application will increase Na-exchangeableto be absorbed by the plant. Anwar (2008) suggests thatKCl substitution by NaCl can increase Na content of feed grass. Conversely, the increased dose of KCl applied will decrease Na nutrient content of upland rice because Na ion is the most easily expelled actions from snoring complex.

4 DISCUSSION

Analysis of variance showed that treatment of NaCl salt at some level of dose did not affect plant height and number of tillers from 4 weeks after plant until harvest time as well as number of productive tillers. This indicated that treatment until dose of 470 mg/polybag did not prevent or inhibit plant metabolic process so there was no growth difference between any NaCl (control) application and dose of 470 mg /polybag.

In some literature, it is stated that the growth of plants in salty environment is directly related to plant resistance to osmotic pressure and poisoning of specific ions such as Na+ and Cl-. Plants that grow in high salt content areas will absorb many ions Na+, Cl- and SO42-. The ions move toward the roots zone through mass flow. Before reaching the critical threshold, ions accumulation is still tolerated by plants so that no toxic effect occurs. This is confirmed by Sabban (2012) which shows no significant decline in tomato growth. Anwar (2008) also reports that NaCl does not reduce significantly the growth of feed grass plants

According to Anwar (2008), the presence of low salt concentration (light salinity) in the early stadia within a certain time can increase the tolerance of plants to heavier salinity stress at the next growth stage.

According to Hawker, et al (1974 in Anwar, 2008), the addition of Na in small amounts will increase vegetative and reproductive growth. Lauci and Epstein (1984 in Baon, et al., 2003) states that the continuous addition of Na will result in Na dominating the soil trap. While other captions are still present in the soil solution, plant growth will get better but when the soil solution has been dominated by Na, the growth will be disrupted.

Generally it can be concluded that substitution of K by Na up to 470 mg/polybag does not suppress any plant growth, but NaCl application can substitute K fertilizer.

KCl substitution will increase plant growth although not statistically different; this is because K requirement is quite high and when K deficiency makes K translocation from the old to young part. Leiwakabessy (1985 in Anwar, 2008) states the process of photosynthesis can be reduced when the K content is low and at that time of respiration increases. This will reduce the supply of carbohydrates that will certainly reduce plant growth.

The research shows that substitution of KCl fertilizer by NaCl does not disturb nutrients uptake of upland rice. This can be seen from leaf nutrient content as a parameter of nutrient status in plants, where NaClapplication actually increases some nutrients such as N, P and Na. Thus the use of NaCl is very beneficial because the upland rice will be more efficient to use fertilizer provided. Similar results were also reported by Berntein and Hayward (1958 in Sabban, 2012) that the administration of NaCl has a role in the growth of the plant if it breaks down it will produce Na^+ and Cl, so that it can maintain the water content in the leaves.

In contrast, the Na leaf content increases with the addition of NaCl. This is a logical consequence because NaCl will increase Na-exchangeable in the soil and will be much absorbed by the plant. In the state of Na that is highly available then K leaf content will becomes low because the function of K to maintain osmotic potential in the leaf vacuole has been replaced by Na. Pitman (1975 in Sabban, 2012) states that Na can replace K on plant leaves but with the process of transport plants that are selective of captions so that K is taken.

Increased nutrients of N, P and K of upland rice due to KCl application is because plants with sufficient K only loses a little water whereas K increases osmotic potential and has a positive effect on stomata closure. Potassium can also function to balance anions and affect the extraction and transport of the anion (Gardner, et al., 2008). In contrast, K deficient plant is unable to close the stomata during hot days so that the water transpiration increases.

5 CONCLUSION

NaCl salt significantly increases the N, P and Na nutrients, but has no significant effect on plant growth, K and Mg nutrients.
KCl fertilizers significantly increase the nutrient content of N, P, K of the plant 8but Na content decreases, and has no significant effect on growth and nutrient content of Mg.

Application of NaCl up to 470 mg/polybag did not show a negative effect7u on the plant.
Substitution of KCl 100% by NaCldoes not suppress the growth and nutrient content of plants does not showsignificant differencein the use of KCl 100%.

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